

The Future of Exposure Assessment: Perspectives from the X2012 Conference

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Abstract

The British Occupational Hygiene Society, in collaboration with the Institute of Occupational Medicine, the University of Manchester, the UK Health and Safety Executive, and the University of Aberdeen hosted the 7th International Conference on the Science of Exposure Assessment (X2012) on 2 July–5 July 2012 in Edinburgh, UK. The conference ended with a special session at which invited speakers from government, industry, independent research institutes, and academia were asked to reflect on the conference and discuss what may now constitute the important highlights or drivers of future exposure assessment research. This article summarizes these discussions with respect to current and future technical and methodological developments. For the exposure science community to continue to have an impact in protecting public health, additional efforts need to be made to improve partnerships and cross-disciplinary collaborations, although it is equally important to ensure that the traditional occupational exposure themes are still covered as these issues are becoming increasingly important in the developing world. To facilitate this, the ‘X’ conferences should continue to retain a holistic approach to occupational and non-occupational exposures and should actively pursue collaborations with other disciplines and professional organizations to increase the presence of consumer and environmental exposure scientists.

Introduction

From July 2nd to 5th 2012, the British Occupational Hygiene Society, in collaboration with the Institute of Occupational Medicine (IOM), the University of Manchester, the UK Health and Safety Executive (HSE) and the University of Aberdeen hosted the 7th International Conference on the Science of Exposure Assessment (X2012) in Edinburgh, Scotland. The ‘X’ conference series has been very influential in the development of the science of exposure assessment, in particular in the field of occupational health and occupational health policy making. It is generally regarded as being the complementary ‘exposure assessment’ partner to the International Conference on Epidemiology in Occupational Health (EPICOH) Conference series organised by the Scientific Committee on

Epidemiology in Occupational Health of the International Commission on Occupational Health (ICOH). The first conference in the X-series was held in 1988 in Woods Hole in the United States, and was followed by conferences in Leesburg, USA (1990); Lyon, France (1994); Gothenburg, Sweden (2001); Utrecht, The Netherlands (2004); Boston, USA (2009); and most recently in Edinburgh (2012).

The X2012 conference specifically aimed to include all areas of human exposure assessment including the general environment, residential and consumer, in addition to occupational exposure, and look at methods to integrate exposure assessments across these fields. The intention was to bring together the leading international experts in these fields and to provide a platform for the exchange of knowledge and expertise. It further aimed to contribute to the development of state-of-the-art methodologies and to improve the knowledge base to effectively control exposure to hazardous agents at work, at home and elsewhere in the general environment.

In total, 325 delegates attended the meeting, which consisted of 173 oral presentations, 29 highlighted discussion posters and 78 research posters. There were dedicated sessions on disaster management, population-based epidemiological studies, health impact assessment, exposure assessment for magnetic resonance imaging, exposure assessment for epidemiological research of clean-up workers following the Gulf of Mexico oil spill disaster (the GuLF Study), UV radiation, and teaching exposure assessment.¹

The conference ended with a special session, chaired by Dr John Howard, Director of the US National Institute for Occupational Safety and Health (NIOSH), at which invited speakers from government, industry, independent research institutes and academia discussed the “Highlights from the conference: implications for research needs and priorities”. The speakers were asked to reflect on the presentations and posters, suggest what may now constitute the important highlights or drivers

¹ Most of the presentation of X2012 can be found at <http://www.bohs.org/x2012presentations/>

of future exposure assessment research and discuss these with an eye on current and future technical and methodological developments. We have summarised the discussions without reference to specific comments or opinions of individuals.

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Issues Raised

Trends and new challenges

The focus of attention, through targeted research funding, in all sectors appears to have shifted away from the more traditional workplace issues and air pollution towards newly emerging exposures that do not have an adequate knowledge base for risk management (because they were not previously recognized as being of concern); most notably research on nanomaterials (Bello, 2012) and disaster management (Scheepers et al., 2012). Despite the importance of continuing to conduct research in these and other emerging topics, the speakers were not convinced that all these areas - most notably research in disaster management - would develop into long term research programmes.

Consumer exposure activities have moved to the forefront of exposure research and are receiving increasing attention (Bakker et al., 2012). This is primarily due to increased interest from industry, stimulated by the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation in Europe, which itself was a response to the growing recognition that existing chemical management policies had failed to effectively identify chemicals of concern, to manage their risks, and to prevent widespread human exposure (Denison, 2007).

It was believed that although funding has shifted to these emerging areas, the traditional issues – e.g. unacceptable occupational exposures - are still with us, particularly in developing countries (e.g. Chaiear et al., 2012), where they also face issues such as inadequate sanitation and lack of clean water along with a high burden of infectious diseases in addition to the usual workplace challenges.

Addressing this “double burden” will require a sustained knowledge transfer from the developed to the developing economies, which should include a more deliberate effort to include scientists from developing countries in future “X” conferences.

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It was further emphasised that despite these emerging topics, it is important to realise that although there are reported to be around 30,000 chemicals in commerce (Muir and Howard, 2006) with a growing number of potentially harmful chemicals incorporated into an expanding portfolio of household products (Glegg and Richards, 2007), the vast majority of exposure research focuses on a narrow subset of agents (Rappaport, 2011; Egeghy et al., 2012). It was argued that the exposure assessment community (and its funders) should consider investing resources to investigate a broader range of chemicals and to “expand its horizons” instead of the narrow focus on a few sentinel substances and emerging areas of interest.

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In emerging areas, especially nanomaterials, prime interest became apparent in the setting of occupational exposure limits (OELs), either to manage established risks or address suspected risks using a precautionary approach. NIOSH has recently suggested exposure limits for carbon nanotubes and carbon nanofibers (NIOSH, 2010) and for ultrafine (including nano-scale) titanium dioxide (NIOSH, 2011). However, the will to set these OELs outpaces the research and attempting to set OELs where the available data are not adequate may store up problems for the future (e.g. legal challenges), and may unnecessarily limit economic competitiveness. Indeed, it was argued that from a regulatory perspective it may be too soon to consider OELs for nanomaterials. In this respect, speakers noted that industry development of new nanotechnologies will require new approaches to assess exposure and health risks. This may include the development of more expertise in hazard banding as an alternative strategy to OELs, which will enable for more chemicals to be assessed, including novel nanomaterials, and as such delivers economic benefits compared with the extensive expenditure on setting individual OELs for only a limited number of substances.

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New methods

Enormous technological progress has been made in exposure assessment in nanotechnology (Bello, 2012), biological agents (McLean et al., 2012; Heederik et al., 2012), and in the development of new measurement devices (Delgado-Saborit et al., 2012; Semple et al., 2012; Proctor et al., 2012). For example, the use of spatial approaches such as tracking devices (Lee et al., 2012), the use of the near-field/far-field concepts in exposure models (Tielemans, 2012; Cherrie et al., 2011) and GIS spatial data (Vermeulen et al., 2012; Volckens et al., 2012; Claudeville et al., 2012; Beranger et al., 2012) to understand exposure were highlighted. The development of sensors that could link exposure to biological response, such as real-time data-logging approaches to measure physiological changes and internal biomarkers, will empower “citizen scientists” to provide data using smart-phone technologies (Dickinson et al., 2010).

However, it was pointed out that even though large volumes of data from the novel techniques mentioned throughout this article are becoming available to scientists, it is important that when analyzing these data those scientists adhere to sound scientific principles in that hypotheses should be developed prior to the actual analysis of the data such that they can be formally tested and can be replicated in field studies. It is important that when newly developed techniques are being used that these are backed up by validation studies to ensure that the findings represent a ‘real’ outcome rather than resulting in unrealistic post hoc conclusions such as those that, for example, haunted especially the early years of genomic epidemiology.

Smaller incremental advances have been made in the methodologies used to assess exposure in epidemiology studies where, despite the rapid advances in other areas, there is still a heavy dependence on questionnaires and other simple tools. For example, when the first X conference was held in 1988, the main focus was on retrospective exposure assessment as the key tool to

understand chronic disease and cancer. Since that first conference, large volumes of measurement data should have become available, and the exposure assessment community should now be able to use these for quantitative historic exposure assessment. There have been some encouraging
4 examples of approaches utilising existing exposure data from across different countries and continents to develop job exposure matrices (e.g. Peters et al., 2012; Olsson et al., 2012).

The development of the concept of “The Exposome” and what the field of “omics” could bring to
8 exposure science is a big step forward in the way exposure to humans is perceived and how it can be assessed at a biological level (Vermeulen, 2012). However, in order for these new technologies to be used to advance exposure science, omics experts and exposure scientists will need to collaborate closely to improve the use and understanding of these measures of exposure and biological effects
12 within integrated projects (van Tongeren and Cherrie, 2012). Bringing specialists in this area of research into the exposure assessment community and thus fully bringing their thoughts and ideas into exposure assessment is expected to significantly improve the understanding and use of biological markers in exposure science.

16 A unifying important challenge that was raised from the regulatory perspective, but which was also echoed by other speakers, was a drive towards more harmonisation at a global level in the way exposures are assessed and recorded and exposure limits set. The conference provided a snapshot
20 of global research activities in exposure modelling and highlighted the value and role of models and associated tools, particularly with respect to the EU REACH Regulation (Tischer et al., 2012; Schinkel et al., 2012; Money, 2012). The speakers agreed that there is a need for high quality contextual information and data to validate these tools. There remains a problem of paucity of exposure data,
24 and more importantly contextual metadata to describe the circumstances in which the exposure occurred and the way the individual behaved during the exposure. The collection of appropriate

contextual data is best achieved within the context of a theoretically-based conceptual model (e.g. Tielemans et al, 2008; Schenider et al, 2011, Gorman Ng et al, 2012).

4 A current challenge is the lack of methodologies to effectively aggregate exposure assessments from
worker, consumer and environmental assessments, although the first methodologies are being
developed (Spankie et al., 2012; Sarigiannis et al., 2012; Bakker et al., 2012). This puts a greater
burden on obtaining additional information on exposure determinants, which not only includes the
8 contextual information for exposure measurements but also extends to consumer and worker habits
and practices. These developments clearly have the potential to be extended to the use of
geospatial assessment as a tool to understand how location can influence exposure. Increased use of
biomonitoring data may further improve the integration of different sources and routes of
12 exposures (Zeman et al., 2012), but it was mentioned that the routine use of human biomonitoring
as an exposure assessment tool has not been fully embraced by all stakeholders.

It was observed that although new markers of exposure and risk are being identified, and new social
16 media-based methods of surveillance are being developed (Eysenbach, 2011), it is critical to ensure
that the people who use these new tools do in fact understand how to interpret the information that
is generated. Tools and models rapidly become increasingly sophisticated, but there is the inherent
danger that as a result of the greater complexity fewer people will be able to use and understand
20 the approaches. However, these trends indicate that the impact of exposure science may well be
increasing, especially if we can further develop the tools to be used in health impact assessments
(e.g. Meijster et al., 2012).

24 *Concluding remarks*

The fields of occupational and non-occupational exposure science have developed largely
independent of each other, probably because of the separation of regulation of these domains in

most countries. Occupational exposure assessment has probably a longer history, with the main emphasis on measuring personal exposure, while for non-occupational exposure assessment (human exposure through environment, indoor, consumer products, etc), tools and models had to be developed to estimate exposure due to the lack of methods to measure personal exposure efficiently. Because of the REACH Regulation which relies on the use of simple tools to assess exposure to many hazardous agents across a vast number of scenarios, and the emergence of sensor technology, allowing personal exposure to be measured cost-effectively in non-occupational populations, these fields are likely to be increasingly convergent. This also means it is important that exposure assessment methods are harmonized so that exposures can be aggregated across these different scenarios to ensure that the risks from all potential health impacts can be assessed appropriately.

For the exposure science community to continue to have an impact in protecting public health additional efforts need to be made to improve partnerships and cross-disciplinary collaborations, including involving disciplines such as biomedical scientists, environmental engineers, economists, urban planners and also behavioural scientists. However, it is equally important to ensure that the traditional occupational exposure themes are still covered as these issues are becoming increasingly important in the developing world, most notably the Asian countries. To facilitate this, it was proposed that the “X” conferences should continue to retain a holistic approach to occupational and non-occupational exposures, and to actively pursue collaborations with other disciplines and professional organisations to increase the presence of consumer and environmental exposure scientists.

Disclaimer: This article has been reviewed and approved for publication by the US Environmental Protection Agency and does not necessarily reflect the views of the Agency or the UK Health and Safety Executive.

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